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Annual Progress Report

Disciplines

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**NORTH CENTRAL
REGIONAL AQUACULTURE CENTER**



ANNUAL PROGRESS REPORT

December 1991

ANNUAL PROGRESS REPORT

For the Period
September 1, 1990 to August 31, 1991

December 1991

North Central Regional Aquaculture Center
13 Natural Resources Building
Michigan State University
East Lansing, MI 48824-1222
Telephone: (517) 353-1962 FAX: (517) 353-7181

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I. INTRODUCTION

Title XIV of the Agriculture and Food Act of 1980 and the Food Security Act of 1985 authorized the establishment of aquaculture research, development, and demonstration centers in the United States (Subtitle L, Sec. 1475[d]) in association with colleges and universities, State Departments of Agriculture, Federal facilities, and non-profit private research institutions. These Regional Aquaculture Centers have been reauthorized in the Food Security Act of 1990. Five such centers have been established: one in each of the northeastern, northcentral, southern, and western regions of the country, and one in Hawaii. As used here, a center refers to an administrative center. Centers do not provide monies for brick-and-mortar development. Centers encourage cooperative and collaborative aquaculture research and extension educational programs that have regional or national application. Center programs complement and strengthen other existing research and extension educational programs provided by the Department of Agriculture and other public institutions. As a matter of policy, centers implement their programs by using institutional mechanisms and linkages that are in place in the public and private sector.

The North Central Regional Aquaculture Center (NCRAC) serves as a focal point to assess needs, establish priorities, and implement research and extension educational programs in the twelve state agricultural heartland of the United States which includes Illinois, Indiana, Iowa, Kansas, Michigan, Missouri, Minnesota, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. NCRAC also provides coordination of interregional and national programs through the National Coordinating Council (NCC) for Aquaculture. The council is composed of directors of regional aquaculture centers and is chaired by a representative of the U.S. Department of Agriculture.

The first Progress Report for the NCRAC covered activities from the inception of the Center on February 1, 1988 through the May 1989. The second covered the period March 1, 1989 through February 28, 1991. On April 11, 1991 the NCC approved an administrative calendar for the Regional Aquaculture Centers. That calendar states that annual progress reports will be submitted to the USDA's Cooperative State Research Service (CSRS) Program Manager between the dates of October 1 and December 1 each year. Therefore, to be in compliance with this calendar this progress report covers the period September 1, 1990 to August 31, 1991. However, it is important to note that these dates overlap two administrative Center budget periods which begin with the grant award date: March 1. At this juncture there have been four starting dates for NCRAC funded research and extension projects: May 1, 1989, March 17, 1990, June 1, 1990 and September 1, 1991. Details of each of these projects and progress through August 31, 1991, except those that began September 1, 1991, are included in the Project Progress Reports section of this document.

II. ORGANIZATIONAL STRUCTURE

Administration of the North Central Regional Aquaculture Center (NCRAC) is shared between Michigan State University and Iowa State University through a memorandum of understanding. The Director is at Michigan State University in East Lansing, Michigan while the Associate Director is at Iowa State University in Ames, Iowa. The NCRAC and fiscal responsibility for its operation is at Michigan State University. The Associate Director at Iowa State University is responsible for all aspects of the Center's publications, technology transfer and outreach activities.

The Board of Directors (BOD) is the primary policy-making body of the NCRAC. The BOD has established an Industry Advisory Council (IAC) and Technical Committee (TC). Membership of the BOD consists of the chair of the IAC, a representative from the regions State Agricultural Experiment Stations and Cooperative Extension Services, a member from a non-land grant university and representatives from the two universities responsible for the center: Michigan State and Iowa State. The IAC is composed of members who represent various sectors of the aquaculture industry and the region as a whole. The TC is composed of a sub-committee for Extension (TC/E) and a subcommittee for Research (TC/R). All twelve states are represented on the TC/E with membership drawn from

individuals who have either Cooperative Extension Service or Sea Grant appointments. The TC/R has broad regional make-up and is composed of scientists from university and state agencies. Each sub-committee of the TC has a chairperson who serves as an ex-officio member of the BOD.

NCRAC functions in accordance with its *Operation Manual* which is periodically amended and updated with BOD approval. It is an evolving document that has changed as the Center's history lengthens. It is used for the development of the cooperative regional aquaculture and extension projects that NCRAC funds.

III. ADMINISTRATIVE OPERATIONS

Since inception of the NCRAC February 1, 1988, the role of the Administrative Center has been to provide all necessary support services to the Board of Directors, Industry Advisory Council, Extension and Research sub-committees of the Technical Committee, and project work groups for the North Central Region as well as representing the region on the National Coordinating Council. As the scope of the NCRAC programs expand this has entailed a greater work load and continued need for effective communication between all components of the Center and the aquaculture community of the region.

The center functions in the following manner. After BOD approval of Administrative Center costs, the Center submits a grant to USDA/CSRS/Awards Management Division for approval. To date the Center has received four grants from USDA for FY88 (Grant #88-38500-3885), FY89 (Grant #89-38500-4319), FY89 (Grant #90-38500-5008) and FY91 (Grant #91-38500-5900) with monies totalling \$2,625,153. The Center annually coordinates a program planning meeting which sets priorities for the upcoming fiscal year and calls for regional workshops to develop project outlines to address the problems identified. Work Groups which are formed at the workshops submit project outlines to the Center who then solicit peer reviews from experts both within and outside of the region. Reviewers responses and Center evaluations are presented to the BOD who then decide which research and extension activities will be funded. The Center conveys BOD decisions to all Project Work Groups and those that are approved for funding are asked to submit revised project outlines incorporating BOD and reviewers comments. The Center then submits the revised project outlines as a Program Plan to USDA for funding approval. Once approved, the Center then prepares subcontracts for each participating institution. The Center receives all invoices for subcontractual agreements and prepares payment vouchers for reimbursement. Thus the Center staff serves as fiscal agent for both receiving and disbursement of funds in accordance with all terms and provisions of the grants. To date the Center is funding eight projects through 89 subcontracts from the four grants received.

As mentioned in the Introduction, NCRAC has funded research and extension projects with three different starting dates. May 1, 1989 marked the initiation of projects on extension, economics/marketing/policy, yellow perch, hybrid striped bass, and walleye. Funding for these projects came from the first two grants that the Center had received: Grant numbers 88-38500-3885 and 89-38500-4319. The extension project received additional monies on March 17, 1990 from Grant #89-38500-4319. On June 1, 1990 projects were begun on walleye, yellow perch, sunfish, hybrid striped bass, salmonids and a regional conference. The walleye, yellow perch and hybrid striped bass projects that began June 1 expanded upon projects that had begun in 1989 by undertaking new objectives. Reports on progress of these reports are presented below in Section IV. The Center received approval for continuation and enhancement of the five projects that received the first allocation of NCRAC funds in May 1989: extension, economics/marketing/policy, walleye, yellow perch, and hybrid striped bass. Funds for these project will be from the FY91 grant and will commence on September 1, 1991. Funding for all Center supported projects is summarized in Table 1 below.

Table 1. North Central Regional Aquaculture Center funded projects.

Project Title	Duration	Funding Level	Grant Number
Extension	5/1/89-4/30/91 3/17/90-8/31/91 9/1/91-8/31/93	\$39,500 \$80,400 \$103,609 \$223,509 <hr/>	88-38500-3885 89-38500-4319 91-38500-5900
Aquaculture Economics, Marketing and Policy for the North Central Region	5/1/89-12/31/91 9/1/91-8/31/92	\$127,338 \$34,350 \$58,300 \$219,988	88-38500-3885 89-38500-4319 91-38500-5900
Advancement of Yellow Perch	5/1/89-8/31/91 6/1/90-8/31/92 9/1/91-8/31/93	\$76,983 \$85,723 \$92,108 \$99,997 \$354,811 <hr/>	88-38500-3885 89-38500-4319 90-38500-5008 91-38500-5900
Advancing Hybrid Striped Bass Culture in the North Central Region	5/1/89-8/31/91 6/1/90-8/31/92 9/1/91-8/31/93	\$68,296 \$68,114 \$101,000 \$96,550 \$333,960	88-38500-3885 89-38500-4319 90-38500-5008 91-38500-5900
Culture Technology of Walleye	5/1/89-8/31/91 6/1/90-8/31/92 9/1/91-8/31/92	<hr/> \$178,981 \$111,657 \$109,223 \$399,861	89-38500-4319 90-38500-5008 91-38500-5900
Culture of Bluegill and Crappie for Food Fish	6/1/90-8/31/92	\$130,758	90-38500-5008
Culture Technology of Salmonids	6/1/90-8/31/92	\$9,000 \$120,799 \$129,799	89-38500-4319 90-38500-5008
North Central Regional Aquaculture Conference	6/1/90-12/31/91	\$7,000	90-38500-5008

NCRAC's 1991 program planning meeting was held at Kansas State University in Manhattan, Kansas on March 2-4, 1991. Executive committees of the Industry Advisory Council (IAC) and Technical Committee (both research and extension subcommittees) met to set priorities for FY92 grant monies. The Board of Directors approved six priority areas and set funding levels for development of project outlines. Workshops for four of those areas were held at Purdue University during June 3-6, 1991: Characterization of Aquaculture Effluents; Culture Technology of Salmonids; Culture of Bluegill and Crappie for Food Fish; and Culture Technology of Walleye. Calls for statements of interest were distributed for the other two areas: Status of Bait Fish Culture in the North Central Region and Evaluation of Native Crayfish Species for Culture in the North Central Region. From these workshops and calls of statements of interest five project outlines were developed during summer 1991 on all but aquaculture effluents. These project outlines will be submitted to the Center by October 1, 1991.

The Center established a Publications Office at Iowa State University that is under the direction of the Associate Director. During this reporting period NCRAC established a Publication Policy that is in keeping with the National Coordinating Council (NCC) Publication Policy. A number of extension fact sheets, several technical bulletins and a video have been submitted to the Publications Office and are in review or final editing stages.

The Center also publishes a newsletter, *NCRAC Journal*, which is sent to over 1,500 persons. This publication provides a showcase for NCRAC activities and reaches a wide audience including federal and state legislators. The editor for the newsletter is the Associate Director of NCRAC.

Other areas of support during this reporting period included monitoring research and extension activities and developing progress reports; preparing project reports for the National Aquaculture Accomplishment Report being compiled by the Northeastern Regional Aquaculture Center; developing liaisons with appropriate institutions, agencies and clientele groups; preparing testimony and coordinating with other regional centers to testify before the U.S. House Appropriations subcommittee on Rural Development, Agriculture and Related Agencies hearing in Washington, D.C.; participating in the National Coordinating Council (made up of the Administrative Directors of the five regions and USDA aquaculture personnel); numerous oral and written presentations to both professional and lay audiences; and working with other fisheries and aquaculture programs throughout the North Central Region.

The Director was invited to participate in the Fifth IR-4/FDA Workshop for Minor Use Drugs: Focus on Aquaculture that was held on October 15-16, 1990 in Bethesda, Maryland. A talk that he presented was published in a supplement to the journal of Veterinary and Human Toxicology. The full citation for that work is as follows:

McNabb, C.D. 1991. An overview of current programs on drug development and regulation for aquaculture: Regional Aquaculture Center perspective. *Veterinary and Human Toxicology* 33 (Supplement 1): 6-7.

He was also an invited participant to a conference entitled "Water Quality and the Environment - Aquaculture" which was held on April 9-10, 1991 in Washington, D.C.

IV. PROJECT PROGRESS REPORTS

A. North Central Regional Aquaculture Center Extension Project

for the period
September 1, 1990 to August 31, 1991

TOTAL FUNDS COMMITTED: \$119,900

WORK GROUP MEMBERS:

Fred P. Binkowski	University of Wisconsin-Milwaukee	Wisconsin
James M. Ebeling	Ohio State University	Ohio
Donald L. Garling, Chair	Michigan State University	Michigan
F. Robert Henderson	Kansas State University	Kansas
Anne R. Kapuscinski	University of Minnesota	Minnesota
Terrence B. Kayes	University of Nebraska-Lincoln	Nebraska
Ronald E. Kinnunen	Michigan State University	Michigan
David J. Landkamer	University of Minnesota	Minnesota
Frank R. Lichtkoppler	Ohio State University	Ohio
Terry A. Messmer	North Dakota State University	North Dakota
Jeffery P. Mittelmark	University of Minnesota	Minnesota
Joseph E. Morris	Iowa State University	Iowa
Robert A. Pierce II	University of Missouri	Missouri
Daniel A. Selock	Southern Illinois University-Carbondale	Illinois
John P. Slusher	University of Missouri	Missouri
David A. Stuber	University of Wisconsin-Madison	Wisconsin
LaDon Swann	Purdue University	Indiana/Illinois
Larry J. Tidemann	South Dakota State University	South Dakota

PROGRESS OF THE WORK GROUP AND PRINCIPAL ACCOMPLISHMENTS

This project involves extension personnel from each of the 12 states of the North Central Region from 14 different universities.

Extension Service personnel in aquaculture serve as liaison between research personnel and several clientele groups. The largest group of clientele are individuals interested in starting an aquaculture operation who lack basic knowledge of aquaculture technologies and opportunities. A second group of clientele have some basic knowledge of aquaculture and sites with potential for aquaculture development. These individuals need more specific information to develop plans for establishing a commercial operation. The third clientele group is comprised of established fish culturists who need information to solve specific problems. A fourth clientele group includes industries involved in production of inputs for aquaculture or in the processing and marketing sectors.

The North Central Regional Aquaculture Center (NCRAC) Extension Project is designed to assess and meet the information needs of the various clientele groups through cooperative and coordinated regional educational programming. However, the demand for aquaculture extension education programs cannot be met by the few specialists in the North Central Region. Therefore, a network of specialists and Cooperative Extension Service (CES) designated contacts has been established to help maximize efficiency of education programs and minimize duplication.

The major actions of this project are to:

- (1) Strengthen linkages between North Central Regional Aquaculture Center research and extension work groups.
- (2) Enhance the North Central Region (NCR) aquaculture extension network for aquaculture information transfer.
- (3) Provide in-service training for Cooperative Extension Service and Sea Grant personnel and other landowner assistance personnel.
- (4) Develop aquaculture education programs for the NCR.
- (5) Coordinate NCRAC publications.

At least one contact person has been designated by CES for each NCR state, an extension contact directory has been developed that is kept current, and a mechanism for sharing materials produced by states in the NCR has been established. Workshops for CES and Sea Grant personnel on how to develop a strong interdisciplinary effort, enhance information sharing, establish priorities for development of educational materials, plan workshops, etc., have been held and will be hosted in additional sites. Liaisons with state and federal agencies, and with state aquaculture organizations have been made to identify industry needs.

Other accomplishments related to the major actions include:

- Assembled and distributed to CES personnel throughout the region an Aquaculture Information Guide, a packet of core materials for in-service training of CES/SG personnel.
- Delivered in-service training programs at the Great Lakes Sea Grant Network meeting in Manitowoc, Wisconsin in October, 1990; the Michigan State University Annual Extension Days meeting in October, 1990; and a combined program for Illinois and Indiana CES Agents in March 1991.
- Produced a listing of 260 salmonid producers within the North Central Region and completed a survey on salmonid egg and fingerling production in 1990.
- Organized and delivered workshops on: Bait Fish Culture (Minneapolis, MN), Fish Transportation (Marion, IL and Lafayette, IN); Crayfish Symposium (SIU, Carbondale, IL); Water Reuse Systems (ISU, Normal, IL); and Fish Diseases (PU, Lafayette, IN).
- Assisted in organizing and delivering the North Central Aquaculture Conference held March 18-21, 1991 in Kalamazoo, MI and moderated 4 sessions: Aquaculture Development (2), Bait Fish Culture, and Water Quality.

IMPACTS ON AQUACULTURE CLIENTELE

The positive impacts to aquaculture clientele from all NCRAC Extension activities are oftentimes hard to measure. However, the formation of the NCRAC Extension network has enabled clientele in states without aquaculture specialists to receive appropriate information for their requests. Direct assistance provided to individuals by the Extension network will enhance the development of aquaculture in the region.

Cooperative Extension Service and Sea Grant personnel who attended aquaculture in-service training are now in a better position to answer questions from clientele who have an interest in aquaculture. Response from the CES Field

staff who received aquaculture handbooks has been very positive. Many of the field staff take information directly from the handbook to disseminate to clientele.

The 1990 Salmonid Egg and Fingerling Production Survey collected essential information regarding trout and salmon egg and fingerling production by aquaculture producers in the North Central Region. There is growing concern over the importation of eggs and fish into the North Central Region from other regions because of the potential to bring new pathogens into the area. Thus it is important to document if the North Central Region could become self-sufficient in salmonid egg and fingerling production in the event that importation from other regions becomes more strongly regulated.

Over 1000 individuals have attended the workshops organized and delivered by the NCRAC Extension Work Group. Clientele attending regional workshops learned of aquaculture development strategies in other areas of the country and acquired information which was of direct use to their own enterprises. For example, individuals attending the workshop on water reuse systems received the following benefits:

1. Providing status of various components in recirculating systems including filtration, aeration and building renovation.
2. Unbiased presentation of the economics of recirculating systems.
3. Advantages and disadvantages of recirculating systems.
4. Opportunity to see actual commercial scale recirculating systems in operation.

The fact sheets developed by this Center will serve to better inform clients about suitable aquaculture practices. In addition, the increased cooperation of various state extension personnel allows for an increased amount of education of the public. The premises behind the regional extension effort is that of cooperation and interaction.

WORK PLANNED FOR NEXT YEAR

Extension work group members will continue to serve as liaisons with each funded NCRAC research project to provide ongoing needs assessment, to provide input for design and prioritization of future research projects, and to identify results useful in extension programs.

Very successful in-service training workshops have been held previously. Based on the results of these workshops, additional regional aquaculture in-service training workshops will be conducted. Indiana-Illinois in-service aquaculture update meetings will be held annually to reinforce previous in-service training. Additional in-service training workshops will be held in Minnesota and tentatively in Ohio. Materials developed for the fourth major action provide the basis for these programs.

At least 6 additional extension fact sheets will be developed by the end of next year. Approved topics include cage culture, fish feeding, fish transport, recirculating systems, and yellow perch culture.

Three regional workshops are planned covering General Aquaculture, Crayfish Culture, and Recirculating Systems.

PUBLICATIONS OR MANUSCRIPTS

NCRAC Extension Publications:

The following Fact Sheets have been submitted to the NCRAC Publications Office at Iowa State University. They are in review or final phases of editing and will be distributed by that office during 1991-92.

Garling, D. Making plans for commercial aquaculture in the North Central Region.

Kohler, S., and D. Selock. Choosing an organizational structure for your aquaculture business.

Morris, J. Channel catfish for the midwest.

Morris, J. Hybrid striped bass culture.

Morris, J. Pond culture of walleye fingerlings.

Swann, L. Use and application of salt in aquaculture.

Swann, L. Transport of fish in bags.

NCRAC Bulletin Series:

The following manuscripts have been submitted to the NCRAC Publications Office at Iowa State University. They are in review or final phases of editing and will be distributed by that office during 1991-92.

Gleckler, D.P. Southern north central region wholesale and retail fish and seafood sellers survey.

Kinnunen, R. North central regional 1990 salmonid egg and fingerling purchases, production, and sales.

Swann, L. Basic overview of aquaculture.

Thomas, S.K., R.M. Sullivan, D.W. Floyd and R.L. Vertrees. Aquaculture law in the North Central states: a digest of state statutes pertaining to the production and marketing of aquaculture products.

*NCRAC Video:*¹

Swann, L. Something fishy: hybrid striped bass in cages.

*Special Publications Supported by NCRAC:*¹

Proceedings of the North Central Aquaculture Conference (These proceedings are from a meeting that was held March 18-21, 1991 in Kalamazoo, Michigan).

¹Similar to the Extension Publications and Bulletin Series this will be made available and distributed by the NCRAC Publications Office at Iowa State University. This office is directed by Joe Morris, Associate Director of NCRAC.

B. Aquaculture Economics, Marketing and Policy for the North Central Region

for the period
September 1, 1990 to August 31, 1991

TOTAL FUNDS COMMITTED: \$161,688

WORK GROUP MEMBERS:

Donald W. Floyd	Ohio State University	Ohio
Mary E. Gerlow	Ohio State University	Ohio
Leroy J. Hushak, Chair	Ohio State University	Ohio
David J. Landkamer	University of Minnesota	Minnesota
Bruce J. Sherrick	University of Illinois	Illinois
Robert L. Vertrees	Ohio State University	Ohio

Extension Liaison:

Frank R. Lichtkoppler	Ohio State University	Ohio
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PROGRESS OF THE WORK GROUP AND PRINCIPAL ACCOMPLISHMENTS

This project seeks to understand the economics, marketing and policy issues of aquaculture in the 12 state North Central Region (NCR). It is a multi-disciplinary effort involving personnel from three institutions in three states and the disciplines of agricultural economics, natural resources policy, and cooperative extension. In addition to the research investigators, there has been a heavy reliance upon a network of producers, regulators, and extension specialists in the 12 state region.

A study of wholesale and retail fish and seafood sellers in the six southern states of the North Central Region (Illinois, Indiana, Kansas, Missouri, Nebraska, and Ohio) was completed. A total of 430 questionnaires were distributed to firms in the industry throughout the six states. There were 107 respondents for a response rate of 30 percent. It showed that cultured products were in general rated equal to superior in quality to wild-caught species. Those characteristics where cultured species ranked the strongest were availability, uniformity of size, continuity of supply, freshness and quality. Over 50 percent of respondents ranked cultured species as somewhat better or superior to wild-caught species for 20 of 22 characteristics. Texture, value and price stability were the only three characteristics where 10 percent or more of the respondents said cultured fish were worse than wild-caught species. The primary freshwater species desired in seafood market channels are walleye, yellow perch, hybrid striped bass, largemouth bass, and bluegill. Research on how to grow some of these species in confinement and policy changes to allow these species to move in commercial channels will be required for feasible production in the North Central states.

An updated survey of marketing channels in the twelve states of NCRAC using a telephone directory based list was carried out. The new sample base included not only wholesale and retail outlets, but in addition brokers, hatcheries and packers. In addition, the questionnaire was modified to overcome several problems with an earlier questionnaire. A total of 1162 questionnaires were mailed to fish and seafood marketing establishments in the NCRAC region, of which 16 were not deliverable, and 293 were returned for a response rate of 25 percent.

Initially a questionnaire was designed to obtain data on production costs and revenues from fish producers in the twelve North Central states. With the large numbers of species and the large numbers of different operations carried out by fish producers in the region (hatching, fingerlings, food fish, stocking, etc.), the resulting questionnaire was exceedingly complex. Because of this complexity, efforts were redirected in two ways.

First, a simplified questionnaire was designed which requested information on species raised, type of operations conducted, revenues, and the nature of the total business. That survey has been completed, being sent to 893 individuals who had been identified as fish farmers in the 12 North Central States in 1990. A total of 453, 51 percent, responded. Of these, 124, or 27 percent of respondents, said they did not belong on a producer list, while another 46, or 10 percent of respondents, were fee-fishing, wild bait fish capture, wholesalers or live haulers only. That leaves 283 respondents, or 62 percent of all respondents, which hatch and/or grow fish in the twelve North Central states. Using that percentage there would be a maximum of 558 legitimate fish producers in the North Central states and probably many fewer since those who did not respond were more likely to fall into the "I don't belong in this list" category.

Of those respondents who are producing fish about 36 percent have been doing so for less than five years, while 28 percent have been in production for over 20 years. Nearly 84 percent defined their operations as sole owner or partnerships. Only 22 percent indicated that their aquaculture operation was part of a larger business. Nearly 70 percent of NCRAC producers responding earned less than 25 percent of their income from fish production. Twenty percent reported no revenues from their aquaculture business, and another 46 percent reported gross revenues of less than \$10,000. Only 13 percent reported gross revenues in excess of \$100,000.

Of the 283 respondents who qualify as producers of fish (hatch or grow on their farm), 80 reported growing fish to foodsize (over 12 inches in length). Some of these 80 are growing fish to these sizes for stocking purposes. In addition, 69 respondents reported growing 6-12 inch stockers, 63 reported growing 2-6 inch fingerlings, 14 reported hatching fry, 10 reported producing eggs, and 16 reported growing bait fish. The most frequently grown species are trout and catfish.

Second, prototype budgets have begun to be developed based on commercially available equipment for various types of aquaculture systems. The most feasible appear to be some of the more intensive type of systems such as recirculating systems. It has been found that there is too much variability in outdoor systems for results to be of value to producers. Outdoor systems are highly subject to the particular soils, sources of water and other unique characteristics of each system. Finally, perhaps in confirmation of what producers have been trying to say, combination systems, especially those which require heating, are too expensive to be feasible in the North Central Region.

Five major resource policy issues for aquaculture in the region were identified. They are regulatory jurisdiction, predator control, water quality, regulation of game and non-native species and environmental contamination. While producers have generally favored the classification of aquaculture as agriculture, in hope of avoiding environmental regulation, the research indicates that there is little reason to believe that such a reclassification will resolve the underlying substantive issues.

Most policies affecting the growth and marketing of fish in NCRAC states are found in state natural resources agencies. They are found in these agencies because they were developed to regulate open access fisheries, and now are the only policies that apply to cultured settings. However, for aquaculture to become more feasible, reconsideration of this regulatory policy framework is necessary. A cautionary and studied approach is suggested for any attempt to revise the regulatory structure that affects fish farmers. Producer issues in many cases have similarities to those for other livestock enterprises, but often in increased intensity because of application in water instead of on land.

USEFULNESS OF FINDINGS

The implications of the economics, marketing and policy project for the future of fish production in NCRAC states are starting to emerge. The most advanced of this work is the policy and regulatory framework research which has clarified the constraints which limit farm production of fish. An examination of how each constraint affects feasibility of producing selected species of fish is needed. Some policies would appear relatively easy to address while others will be extremely difficult. At the easy end of the spectrum are policy changes which would allow commercial marketing of farm raised species which are designated as game or sport fish, such as walleye or largemouth bass. At the difficult end are issues of effluent discharge regulations and the use of medication/chemicals in water to control fish disease.

The marketing work shows that cultured species are well-accepted in commercial seafood marketing channels. They were viewed as somewhat better to superior to wild-caught fish by a majority of seafood market channel respondents for 20 of 22 characteristics. Major problems, particularly in the North Central states is to develop standardized marketing channels in those markets where producers can compete.

The least developed part of this project is the economic feasibility of producing fish species in the North Central Region. Given the space and water constraints in most areas of the region, it appears that fish production in this area must focus on producing high valued species for niche markets, where relatively low volumes of high-valued product are competitive. The recreational value of the Great Lakes eliminates these as sources of water for cage production of fish. Effluent discharge constraints will limit use of other water sources because of urban competing uses. The intensive level of crop production in most of the midwest means that fish production must generate high per unit rents to the land/space used.

WORK PLANNED FOR NEXT YEAR

The first Situation and Outlook Report is expected to be completed by December 31, 1991. Feedback on how the utility of the report can be increased will be sought from producers. Work on the second Report will begin near the end of the contract year.

Completion of the marketing analysis and generation of research and other reports of those results will continue.

The next phase of the production study will be to develop and establish production or propagation budgets for selected fish species in the North Central states using real data obtained from producers. First, use of the completed producer surveys will be used to identify prominent species and prominent types of production facilities in the region in order to target the most important types of firms for development of budgets. Two to four species/facility types will be selected for budget development. Second, questionnaires will be developed which are tailored to the targeted species/facilities, and which are much shorter than earlier prototype questionnaires.

Questionnaires will be pretested by visiting selected production facilities which have the targeted species/facilities. Then they will be administered to highly selective groups of producers by species and by type of facility. To increase response rate, a combination of mail and telephone instruments will be used, with presurvey education being carried out by the extension component of the project, which appeared to be highly effective in the completed producer survey.

The most critical element of the educational program remains in developing the credibility of NCRAC and the economics, marketing and policy project. There will be an effort to continue to build contacts with state agencies that have an interest or role in commercial aquaculture (e.g., natural resources, environmental licensing/permitting, and agriculture agencies), state aquaculture associations, state extension services, Sea Grant programs and economic development groups in each of the states within the North Central Region to seek input and support for the information gathering program. Key individuals respected in the aquaculture industry will be chosen from these groups to

facilitate legitimation and results will be presented through appropriate industry publications and other applicable communication channels.

PUBLICATIONS OR MANUSCRIPTS

Publications in print:

Floyd, D.W., R.M. Sullivan. 1990. Natural resources and aquaculture: the policy environment in the North Central states. Proceedings of the third symposium on social science and resource management. Texas A&M University, College Station, Texas.

Floyd, D.W., R.M. Sullivan, R.L. Vertrees and C.F. Cole. 1991. Natural resources and aquaculture: Emerging policy issues in the North Central states. *Society and Natural Resources* 4:123-131.

Thomas, S.K. 1991. Industry association influence upon state aquaculture policy: a comparative analysis in the North Central region. M.S. thesis. Ohio State University, Columbus.

Thomas, S.K., R.L. Vertrees and D.W. Floyd. 1991. Association influence upon state aquaculture policy--a comparative analysis in the North Central region. *The Ohio Journal of Science* 91(2):54.

Approved manuscripts:

Brown, G.J., and L.J. Hushak. (In press). The NCRAC producers survey and what we have learned: An interim report. Pages 69-71 in *Proceedings of the North Central Aquaculture Conference*, Kalamazoo, Michigan, March 18-21, 1991.

Gleckler, D.P. (In press). Southern north central region wholesale and retail fish and seafood sellers survey. M.S. Thesis. Ohio State University. (To be published in the NCRAC Bulletin Series)

Gleckler, D.P., L.J. Hushak, and M.E. Gerlow. (In press). Distribution channels for wild-caught and farm-raised fish and seafood: A survey of wholesale and retail buyers in six states of the North Central Region. Pages 77-81 in *Proceedings of the North Central Aquaculture Conference*, Kalamazoo, Michigan, March 18-21, 1991.

Hushak, L.F., D.W. Floyd and R.L. Vertrees. (In press). The aquaculture industry: is growing fish a competitive enterprise in North Central states? *Ohio's Challenge*

Robinson, M., D.F. Zepponi, and B.J. Sherrick. (In press). Assessing market potential for new and existing species in the North Central Region. Pages 72-76 in *Proceedings of the North Central Aquaculture Conference*, Kalamazoo, Michigan, March 18-21, 1991.

Thomas, S.K., R.M. Sullivan, D.W. Floyd and R.L. Vertrees. (In press). Aquaculture law in the North Central states: a digest of state statutes pertaining to the production and marketing of aquaculture products. (To be published in the NCRAC Bulletin Series)

C. Advancement of Yellow Perch Aquaculture

for the period
September 1, 1990 to August 31, 1991

TOTAL FUNDS COMMITTED: \$160,206

WORK GROUP MEMBERS:

Fred P. Binkowski	University of Wisconsin-Milwaukee	Wisconsin
Paul R. Brown	Purdue University	Indiana
David A. Culver	Ohio State University	Ohio
Konrad Dabrowski	Ohio State University	Ohio
Donald L. Garling	Michigan State University	Michigan
Terrence B. Kayes, Chair	University of Nebraska-Lincoln	Nebraska
Jeffrey A. Malison	University of Wisconsin-Madison	Wisconsin
James E. Seeb	Southern Illinois University-Carbondale	Illinois
Robert J. Sheehan	Southern Illinois University-Carbondale	Illinois

Extension Liaison:

Donald L. Garling	Michigan State University	Michigan
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PROGRESS OF THE WORK GROUP AND PRINCIPAL ACCOMPLISHMENTS

This project is examining: (1) the suitability of selected wild perch stocks obtained from different geographic areas as candidates for brood stock development, (2) the applicability of selected conventional production technologies to perch aquaculture, (3) the potential of using chromosomal triploidy induction to enhance growth, and (4) the relative merits of pond versus intensive culture methods for the production of perch fingerlings. The project is being carried out cooperatively by investigators from seven different institutions in six states.

Workers at Southern Illinois University-Carbondale (SIU-C), University of Wisconsin-Madison (UW-Madison), and University of Wisconsin-Milwaukee (UW-Milwaukee) have collected wild broodfish and obtained fertilized eggs and young-of-the-year fish from Lake Mendota (Wisconsin) and Green Bay (Wisconsin), Linesville (Pennsylvania) and Prquimans River (North Carolina) stocks. UW-Milwaukee has compared the survival and growth of early life history perch reared intensively in the laboratory and provided juvenile perch to Purdue University. Purdue researchers have compared the survival, growth, feed conversion and body composition of the difference stocks reared at different temperatures.

Juvenile perch have been successfully reared by a standardized scheme developed by UW-Milwaukee. The Prquimans River perch exhibited better survival, were produced at much higher rearing densities, accepted practical starter diet at an earlier age, and had a higher percentage of swim bladder inflation than the other stocks. However, there were no differences in length growth of perch smaller than 40-50 mm TL. At near optimum growth temperatures (about 22 °C) differences in juvenile growth between strains were not significant, but the strains grew at different rates when reared at other than optimum temperatures (16 or 28 °C). Weight gains by the Prquimans River stock were significantly higher than the Lake Mendota stock at all three experimental temperatures.

Investigators at Michigan State University (MSU) demonstrated that the optimum loading rate for intensive culture of perch is between 1.1 and 1.4 kg of fish/L/min water flow and that about 3.5 mg/L of dissolved oxygen is necessary to maintain optimal growth. The maximum rearing density of perch is at least 85 kg fish/m³ rearing space. Peak

oxygen consumption rates were about 220 mg O₂/kg per hour occurring about 1 h after each feeding. The overall mean oxygen consumption rate for the entire 11 hr period was 173 mg O₂/kg/h and perch require about 136 g O₂/kg feed.

UW-Madison researchers have demonstrated that age-0 perch fingerlings can be successfully raised in net-pens in small ponds. Groundwater addition to the ponds offers several important benefits including moderation of seasonal temperature extremes and better maintenance of dissolved oxygen levels during prolonged periods of cloudy weather. Growth of fish over-wintered in ponds in net pens was significantly less than those over-wintered in tanks supplied with groundwater. The fish held in ponds lost weight during the fish held in the relatively warmer tanks exhibited significant gain in weight and length. Data collection has recently ended for a comparison of fish grown in net-pens in ponds with or without groundwater addition and has not been analyzed.

SIU-C investigators have compared the growth of diploid and triploid perch nearing sexual maturity to determine if triploidy improves growth in older fish. No significant differences were observed in growth of diploids or triploids grown separately; but, triploid perch grew better than diploids when grown together. The data suggests that all-triploid production of perch will not improve growth rates.

Comparisons of pond reared and intensively lab cultured perch fry at UW-Milwaukee and Ohio State University (OSU) indicated that: (1) regardless of rearing method, developing perch eggs and embryos are subject to variable, high levels of mortality during incubation; (2) the survival of fry reared in ponds is dramatically higher than those reared in intensive culture systems; (3) the high mortality levels of intensively reared fry are associated with cannibalism, swim bladder inflation problems, and a high incidence of spinal deformities; (4) the subsequent growth rates of perch fry cultured in ponds or reared intensively do not differ significantly, and (5) the growth of fry in ponds varies with temperature.

OSU investigators have observed that the differentiation of the stomach and pyloric caeca of the intestine were related to fish age and size. A distinguishable stomach is apparent at a body weight of approximately 10 mg. The digestive tract resembles the adult form at 100 mg body weight. Initial diets of pond reared fry are calanoid copepods until the fish reaches 24-44 mm followed by cyclopoid copepods and cladocerans. Amino acid compositions of perch did not differ from fish reared in Ohio or Wisconsin. Pond reared fish had higher levels of docosahexaenoic (22:6w3) and eicosapentaenoic (20:5w3) than their major food item (*Daphnia*) which suggests that diets enriched in these fatty acids may be appropriate for perch.

USEFULNESS OF FINDINGS

Differences in growth of yellow perch stocks reared at extreme temperatures indicate that producers should select stocks that have proven growth potential and that will grow best under their specific conditions.

Yellow perch can be reared successfully in intensive flow-through systems or in net-pens in small ponds. The optimum loading rates, density data, and oxygen consumption data can be used to project production at planned facilities. Perch raised in net-pens can benefit from groundwater addition to extend the growing period and maintain pond water quality. Pond culture in cold climates may be a cost effective method to raise yellow perch. The availability of ground water to moderate summer and winter temperature extremes and flush excess nutrients from the ponds may markedly improve the production efficiency of pond culture.

Constraints on intensive laboratory larval perch culture have been identified and must be overcome before they are commercially viable. Pond production methods for fingerlings avoid these difficulties; but, can be expected to vary with environmental conditions. Pond fry feeding studies may indicate potential practical fry diet improvements.

WORK PLANNED FOR NEXT YEAR

A Great Plains perch stock will be obtained by the University of Nebraska-Lincoln (UN-L) and UW-Madison and compared to the Lake Mendota strain by Purdue. MSU research will compare the performance of perch reared at a commercial facility in raceways with baffles or with multiple passes at optimum loading and high densities to previous lab studies. Net-pen culture experiments will be repeated by UW-Madison to compare growth to the previous cool summer growth season. The analysis of intensive lab and pond reared perch fry will be completed. Additional work on timing of adaptability of pond reared fingerlings to intensive culture will be done by UW-Madison and OSU.

PUBLICATIONS, MANUSCRIPTS OR PAPERS PRESENTED

Publications in print:

Dabrowski, K., and D.A. Culver. 1991. The physiology of larval fish: Digestive tract and formulation of starter diets. *Aquaculture Magazine* 17(2):49-61.

Glass, R.J. 1991. The optimum loading and density for yellow perch (*Perca flavescens*) raised in a single pass, flow through system. M.S. thesis. Michigan State University, East Lansing.

Approved manuscripts:

Garling, D.L. (In press). NCRAC research programs to enhance the potential of yellow perch culture in the North Central Region. Pages 253-255 in *Proceedings of the North Central Regional Aquaculture Conference*, Kalamazoo, Michigan, March 18-21, 1991.

Malison, J.A., and J.A. Held. (In press). Effects of fish size at harvest, initial stocking density and tank lighting conditions on the habituation of pond-reared yellow perch (*Perca flavescens*) to intensive culture conditions. *Aquaculture*

Williams, F., and C. Starr. (In press). The path to yellow perch profit through planned development. Pages 49-50 in *Proceedings of the North Central Regional Aquaculture Conference*, Kalamazoo, Michigan, March 18-21, 1991.

Papers presented:

Malison, J.A., J.A. Held, L.S. Procarione, T.B. Kayes, and C.H. Amundson. 1991. The influence on juvenile growth of heat and hydrostatic pressure shocks used to induce triploidy in yellow perch. 1991 Annual Meeting of the American Fisheries Society, September 8-12, 1991, San Antonio, Texas.

Malison, J.A., J.A. Held, and C.H. Amundson. 1991. Factors affecting the habituation of pond-reared yellow perch (*Perca flavescens*), walleye (*Stizosiedion vitreum*), and walleye-sauger hybrids (*S. vitreum* female x *S. canadense* male) to intensive culture conditions. 22nd Annual Meeting of the World Aquaculture Society, June 16-20, 1991, San Juan, Puerto Rico.

Submitted manuscripts:

Malison, J.A., T.B. Kayes, J.A. Held, T.B. Barry, and C.H. Amundson. Manipulation of ploidy in yellow perch (*Perca flavescens*) by heat shock, hydrostatic pressure shock, and spermatozoa inactivation. *Aquaculture*

Dabrowski, K., D.A. Culver, C.L. Brooks, A.C. Voss, H. Sprecher, F.P. Binkowski, S.E. Yeo, and A.M. Balogun. Biochemical aspects of the early life history of yellow perch (*Perca flavescens*). Proceedings of the International Fish Nutrition Symposium, Biarritz, France, June 25-27, 1991.

D. Advancing Hybrid Striped Bass Culture

for the period
September 1, 1990 to August 31, 1991

TOTAL FUNDS COMMITTED: \$135,160

WORK GROUP MEMBERS:

George G. Brown	Iowa State University	Iowa
Terrence B. Kayes	University of Nebraska-Lincoln	Nebraska
Christopher C. Kohler, Chair	Southern Illinois University-Carbondale	Illinois
Jeffrey A. Malison	University of Wisconsin-Madison	Wisconsin
Robert J. Sheehan	Southern Illinois University-Carbondale	Illinois

Extension Liaison:

Joseph E. Morris	Iowa State University	Iowa
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PROGRESS OF THE WORK GROUP AND PRINCIPAL ACCOMPLISHMENTS

The goal of this research is to address key problems that pertain to the development of commercial hybrid striped bass culture in the North Central Region. The research has focused on maintaining captive brood stocks of both white bass and striped bass, obtaining out-of-season spawning, development of procedures for storage and transport of gametes, and feeding strategies for intensive culture of larvae. The project is being carried out cooperatively by investigators from three different institutions in three states.

Over 600 adult white bass (*Morone chrysops*) have been collected by Southern Illinois University-Carbondale (SIU-C) researchers. More than 90 percent of these fish have been trained to accept dry trout feed. SIU-C researchers have noted that white bass can be readily sexed with 80-90% accuracy, even if they are not in spawning condition.

A reciprocal arrangement has been made to exchange captive white bass for captive striped bass (*Morone saxatilis*) from Virginia Polytechnic Institute and State University (VPI) and Crane Aquaculture Research Center, Baltimore, Maryland. This project does not currently require striped bass.

A detailed set of protocols for sampling adult-size white bass in the field for reproductive readiness has been developed by University of Wisconsin-Madison (UW-Madison) researchers. Fish captured in April were determined to be in the pre-spawn stage of development while white bass spawning were nearing or at completion of spawning in May. Reproductive indices of fish samples in May were significantly lower for these fish than those sampled in April. By November, numerous reproductive indices increased.

In summer 1990, approximately 300 white bass were placed into three separate water reuse systems at SIU-C: (1) normal-cycle (normal photoperiod and temperature), (2) compressed-cycle (cycle compressed to nine months) or (3) constant-cycle (temperature constantly at or above spawning temperatures (20 ± 5 °C)). Human chorionic gonadotropin (HCG) was used to successfully spawn compressed-cycle fish in March 1991, the normal-cycle fish in May 1991, and the constant-cycle fish in May 1991. Attempts to induce constant-cycle fish in March 1991 failed.

All seven white bass compressed-cycle females injected with HCG produced eggs on March 20, 1991. Percent hatch was zero for one fish, low in three others and very good for the remaining three fish. Percent hatch and percent viable offspring was virtually equal irrespective of sperm source (compressed- and constant-cycle males).

Five of the seven normal-cycle females (HCG-injected) produced eggs on May 4, 1991. Percent hatch was very good in four of five spawns. Percent hatch and percent viable offspring resulting from constant- and normal-cycle males was virtually equal.

Four HCG-injected constant-cycle females produced eggs on the same date as normal-cycle females. Fertility rates of sperm from constant-cycle and normal-cycle males were essentially equal in all but one case.

A joint effort between SIU-C, University of Maryland and North Carolina State University researchers resulted in the first documented volitional tank spawning of striped bass females and white bass males. Striped bass females were seven years old and raised from larvae while the male white bass were 'wild' stock that had been trained to prepared diets for one year. Some fertilized eggs were recovered.

Protocols for the successful collection, short-term and long-term storage and transportation of gametes have been developed collaboratively between Iowa State University (ISU) and SIU-C. White bass semen was collected from three groups of fish: those that were injected monthly with HCG, injected weekly or were not injected. Monthly HCG injections proved superior, with greater numbers of spermatozoa. Mobility tests and metabolite tests were similar across treatments. Extended semen samples, using sodium chloride, had greater sperm mobility after shipment than non-extended samples.

USEFULNESS OF FINDINGS

SIU-C researchers have successfully captured adult white bass, acclimated them to tank culture conditions, and trained them to accept formulated feed. Some fish have been held in captivity for over two years. It is not known if this level of domestication has been achieved for white bass in any other laboratory or commercial enterprise.

An alternative procedure for measuring reproductive hormone level has been noted. This method will continue to be evaluated. This method will have a great potential for practical application in aquaculture.

White bass has been successfully spawned out-of-season. In addition, tank-spawn of white bass with striped bass has been accomplished. These two occurrences serve to improve the future of hybrid striped bass culture.

Results strongly suggest that successful routine collection, shipment and short- and long-term storage of *Morone* semen are feasible. Monthly HCG injections increased sperm count as well as volume while extension with a sodium chloride solution helped preserved semen. Thus, if *Morone* semen must be stored prior to use for more than 30 days, cryopreservation appears to be the best option.

The methods developed by SIU-C and ISU will permit regional producers the ability to store white bass and striped semen and to hybridize the two species. Both short-term (one month) refrigerated seminal storage and indefinite cryostorage methods were developed; however, the later requires a greater level of technical expertise on the part of the culturist.

WORK PLANNED FOR NEXT YEAR

Additional white bass will be collected and trained to formulated feed. East Coast researchers will supply the striped bass when they are required. However, a source of wild striped bass in Kentucky has been identified and will be used pending issue of collection permits.

White bass serum and tissue samples will continue to be analyzed and new procedures refined.

An attempt to spawn white bass will be done in early-February 1992. Tank-spawning of white bass will also be tried. Various hormonal manipulations may also be attempted. In addition, trials of various larval feeds, which were unsuccessful in 1991 due to unavailability of fish, will be repeated in 1992.

Fertility tests using extended semen of various sperm motilities and cryopreserved semen of varying volumes will be done in an attempt to determine if: (1) sperm motility is directly related to fertility and (2) whether a greater number of spermatozoa can improve fertility when using semen with reduced semen motility. Attempts will be made to cryopreserve white bass eggs and embryos.

PUBLICATIONS, MANUSCRIPTS OR PAPERS PRESENTED

Approved manuscripts:

Kohler, C.C. and R.J. Sheehan. (In press). Hybrid striped bass culture in the North Central Region. Pages 207-209 in Proceedings of North Central Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Papers presented:

Habicht, C., R.J. Sheehan, C.C. Kohler, G.G. Brown, and L. Koutnik. 1991. Routine collection, storage, and shipping of white bass sperm. 29th Annual Meeting Illinois Chapter of the American Fisheries Society, Champaign, IL.

Submitted manuscripts:

Woods, L.C., C.C. Kohler, R.J. Sheehan, and C.V. Sullivan. Volitional tank spawning of female striped bass with male white bass produces hybrid offspring. Transactions of the American Fisheries Society

E. Culture Technology of Walleye

for the period
September 1, 1990 to August 31, 1991

TOTAL FUNDS COMMITTED: \$177,731

WORK GROUP MEMBERS:

Thomas G. Bell	Michigan State University	Michigan
Frederick W. Goetz	University of Notre Dame	Indiana
Anne R. Kapuscinski	University of Minnesota	Minnesota
Terrence B. Kayes	University of Wisconsin-Madison	Wisconsin
Jeffrey A. Malison	University of Wisconsin-Madison	Wisconsin
James E. Seeb	Southern Illinois University-Carbondale	Illinois
Lisa W. Seeb	Southern Illinois University-Carbondale	Illinois
Robert J. Sheehan	Southern Illinois University-Carbondale	Illinois
Robert C. Summerfelt, Chair	Iowa State University	Iowa
Bruce L. Tetzlaff	Southern Illinois University-Carbondale	Illinois
Allan L. Trapp	Michigan State University	Michigan

Extension Liaison:

Anne R. Kapuscinski	University of Minnesota	Minnesota
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PROGRESS OF THE WORK GROUP AND PRINCIPAL ACCOMPLISHMENTS

The goal of the research is to improve the technology for commercial walleye aquaculture. The research has focused on several critical bottlenecks to commercial production: (1) lack of procedures for manipulating reproduction and inducing spawning in walleye brood stock; (2) the lack of captive domesticated brood stock; (3) the need to improve pond management for fingerling production; and (4) mortality of fry reared in intensive culture systems due to non-inflation of the gas bladder (NGB). The walleye project is being carried out cooperatively through five sub-projects, each involving two or more institutions and cooperators from several state natural resource agencies (Iowa, Kansas, Minnesota, Ohio) and the U.S. Fish and Wildlife Service in North Dakota and Wisconsin.

Studies on the endocrine and gonadal changes which occur during the annual reproductive cycle of walleye are being carried out cooperatively by investigators at the University of Wisconsin-Madison (UW), Southern Illinois University-Carbondale (SIU-C), University of Minnesota (UM) and University of Notre Dame (UND), along with cooperating state and federal agencies in Minnesota and Wisconsin. SIU-C and the UM are responsible for the field collection and processing of blood and tissue samples from adult walleye from the wild and walleye held in ponds. The UW have developed and validated methods for directly measuring levels of estradiol-17 β (E₂) and testosterone (T) in walleye serum. For E₂, a commercially available solid-phase-antibody radioimmunoassay (RIA) with an iodinated tracer ligand (Coat-a-Count Estradiol, Diagnostic Products Corporation [DPC], Los Angeles, CA) was adapted and validated. To measure T, both a solid-phase-antibody RIA (Coat-A-Count, DPC) and a double-antibody RIA (DPC) have been similarly validated. Histological procedures that produce acceptable results in evaluating adult walleye gonads at all (seasonal) stages of development were also developed and standardized.

To date, gonadal development and sex-steroid levels taken during the same season are similar for wild-caught walleyes and walleyes held in ponds. Gonadal growth in male walleye begins in August or September, and testes are in an advanced stage of development as early as January. In fact, mature spermatozoa can be expressed from males

collected from January through the spawning season. In female walleyes, gonadal growth also begins in late summer. By early January vitellogenesis is nearing completion, as evidenced by the high gonadosomatic indices (GSIs) of females collected at this time. Researchers at the UW have also started work to identify and characterize the steroids responsible for final oocyte maturation and ovulation in walleye. Of the various steroids tested, 17, 20-DHP and 17,20,21-THP were the most potent at inducing ovulation in walleye oocytes cultured *in vitro*.

UW investigators have also cultured oocytes *in vitro* with radiolabelled precursors and human chorionic gonadotropin (HCG) in order to isolate steroids produced by the ovarian tissues and released into the culture media during final oocyte maturation. Results indicated that little or no 17,20,21-THP and only a moderate amount of 17,20-DHP were produced.

To increase the economic viability of walleye aquaculture there is a need for development of selected strains of captive domesticated brood that are adapted to environmental and feeding regimes used in commercial production. A component of this project is working towards this goal beginning with a profile of the genetic variation within populations in different geographical areas of the region. Selected stocks are being evaluated for performance at ISU and biochemical analysis at SIU-C on these and other stocks to identify their genetic composition.

Studies by ISU at the two U.S. Fish and Wildlife Service hatcheries in North Dakota at Valley City and Riverdale involves controlled experimentation to evaluate zooplankton seeding, pond fertilization, and clam shrimp control strategies. The study has developed 51 pond-years of data. The experiment involves comparing ponds with and without zooplankton inoculation, and alfalfa meal, pellets and ground hay, and soybean meal for fertilization. Over both years and hatcheries, average fish survival was 53.9% (211,834 fry/hectare), and biomass production 45.7 kg/hectare. There were no significant differences in survival or fish production (kg/hectare) by type of fertilizer used in ponds, but fish survival was lower. Because of lower survival, fish production (kg/hectare) was also lower in ponds receiving the zooplankton inoculation. Copepods were less abundant but cladocera more abundant in ponds inoculated with large cladocera (*Daphnia*) than in ponds left uninoculated. This suggests a competitive interaction between the larger-sized cladocera derived from the inoculum and copepods that normally dominate the zooplankton community shortly after filling. There was a significant positive correlation between fish survival and abundance of copepods in the second week of culture, abundance of cladocera in the third and fourth weeks of culture and between abundance of chironomids in the sixth week of culture. This sequence parallels the patterns observed in walleye fingerling feeding habits in the same ponds. Chironomid response to the zooplankton inoculation was inconsistent. Generally, ponds fertilized with small particle size materials (alfalfa meal and soybean meal) had more copepods than ponds fertilized with alfalfa pellets or hay, but the abundance of cladocerans was unaffected by the type of organic fertilizer. Chironomids were more abundant in ponds fertilized with alfalfa materials than ponds fertilized with soybean material.

The presence and proper function of the gas bladder is essential for fish to maintain their position in the water column allowing them to adjust their specific gravity to obtain neutral buoyancy without an undue expenditure of energy in swimming. Noninflation of the gas bladder (NGB) is a pathological condition that results in high mortality of young fish and its cause has not been determined. In intensive culture of larval walleye, NGB is quite prevalent. To uncover this cause of NGB, a collaborative effort between ISU researchers and veterinarians at the Animal Health Diagnostic Laboratory at Michigan State University (MSU) was initiated in May 1989. Researchers at ISU reared larval walleye on formulated feeds, carefully monitored water chemistry, and provided over the last two years numerous specimens to veterinary pathologist at MSU. In turn, they have examined the fry to determine the normal histology of the gas bladder and to identify pathological lesions that would reveal the cause for NGB.

USEFULNESS OF FINDINGS

The information gained in this project should provide the basic knowledge needed to develop practical methods of controlling reproduction and inducing out-of-season spawning.

Maintenance of captive domesticated brood stock and improved genetic lines of walleye should lead to economic viability for commercial production in the North Central Region.

The present study was the first to evaluate the zooplankton inoculation as a management strategy for pond culture of walleye. The findings indicate that a zooplankton inoculum can have significant influence on the zooplankton community when the inoculum contains large cladocera. The particle size of different types of alfalfa (meal, pellets, and ground hay) and soybean meal may have selective effects on zooplankton communities, but at normal application rates, fish production is similar. New ponds at a hatchery with chronic clam shrimp problems do not have clam shrimp problems, an infestation for at least a year or more is required to buildup a sufficient population of resistant eggs of the clam shrimp before they become a serious pest. In laboratory experiments, turbidity increased in direct proportion to clam shrimp density, providing experimental support for the common observation that clam shrimp increase the turbidity of ponds where they are abundant.

Noninflation of the gas bladder (NGB) has been the major bottleneck to advancement of intensive culture of larval walleye and other fishes such as striped bass. The present study provides description of the histology of the gas bladder and the nature of inflammatory and degenerative changes that occur in the organ's epithelium in fish that have not inflated the gas bladder. These findings provide insight into cultural conditions that suggest that surface films that contain oil, debris, bacteria, and small particles of fish feed may cause the problem.

WORK PLANNED FOR NEXT YEAR

Immunoassay and histological analyses of walleye serum and tissue samples collected by UM and SIU-C will continue. In addition, UW will continue to characterize the maturational steroids in walleye, develop and validate assays for these steroids, and measure these hormones in blood samples collected from wild-caught and pond-held adult fish. Progress has already been made in developing an enzyme-linked immunoassay (ELISA) for 17,20-DHP. UW researchers have obtained an antibody and are currently producing a 3-CMO conjugate to 17,20-DHP.

A third field season will be carried out at the Garrison Dam National Fish Hatchery, Riverdale, North Dakota to complete studies on the ecology of clam shrimp in the culture ponds. Correlations will be run between clam shrimp density and pond turbidity, chlorophyll *a*, and Secchi disk, and fish production to determine the relationship between ponds water quality, fish production variables and clam shrimp presence and abundance.

Histological studies of the larval walleye collected in the 1991 culture season will be completed and the data from the 1991 season summarized. Environmental data on water quality will be related to the incidence of NGB. Findings from the three year study will be summarized.

Walleye will be collected from several sites throughout the North Central Region, including those stocks used to develop baseline information on biochemical genetic composition of walleye populations for potential use as brood stock. Walleye eggs will be acquired from a minimum of three sources of brood stock from the region and reared extensively at SIU-C and intensively at ISU to evaluate the performance of the stocks to determine their suitability for different types of cultural environments.

PUBLICATIONS, MANUSCRIPTS OR PAPERS PRESENTED

Publications in print:

Clouse, C.P. 1991. Evaluation of zooplankton inoculation and organic fertilization for pond-rearing walleye fry to fingerlings. M.S. thesis. Iowa State University, Ames.

Papers presented:

Clouse, C. 1991. Evaluation of zooplankton inoculation and organic fertilization for pond-rearing walleye fry to fingerlings. 1991 Coolwater Fish Culture Workshop, January 7-9, 1991, Springfield, Illinois.

Summerfelt, R.C., C. Clouse, and L. Harding. 1991. Pond production of fingerling walleye in the Northern Great Plains. 121st Annual Meeting of the American Fisheries Society, September 8-12, 1991, San Antonio, Texas.

Submitted manuscripts:

Summerfelt, R.C., C. Clouse, and L. Harding. Pond production of fingerling walleye in the Northern Great Plains. *Journal of Applied Aquaculture*

F. Culture of Bluegill and Crappie for Food Fish

for the period
September 1, 1990 to August 31, 1991

TOTAL FUNDS COMMITTED: \$130,758

WORK GROUP MEMBERS:

Donald L. Garling	Michigan State University	Michigan
James E. Seeb	Southern Illinois University-Carbondale	Illinois
Lisa W. Seeb	Southern Illinois University-Carbondale	Illinois
Robert J. Sheehan	Southern Illinois University-Carbondale	Illinois
Bruce L. Tetzlaff, Chair	Southern Illinois University-Carbondale	Illinois

Extension Liaison:

Fred P. Binkowski	University of Wisconsin-Milwaukee/Center for Great Lakes Studies	Wisconsin
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PROGRESS OF THE WORK GROUP AND PRINCIPAL ACCOMPLISHMENTS

This project seeks to control sunfish reproduction through selective breeding and chromosome manipulation and to determine optimum rearing conditions for various sunfish and their hybrids. Modifications of techniques used to manipulate ploidy in other groups of fish, are being evaluated to develop optimal means of controlling sex determination and producing sterile sunfish.

The techniques being used involve the application of temperature or pressure "shocks" to induce the retention in the developing eggs of additional sets of chromosomes that would normally be split off with the polar bodies during the process of oogenesis.

In 1990 MSU produced the first verified triploid bluegills through temperature shock induced polar body retention. The MSU workers also improved on the rearing time required before treated fish can be evaluated for ploidy level by devising a technique that uses 5-7 day old larvae rather than 3 month old fish.

At the same time, SIU-C workers, comparing pressure and temperature shocking techniques, found that hydrostatic pressure shocks were superior. One hundred percent triploids were produced at several pressure levels with good survival and no deformed individuals. Also at SIU-C irradiated sperm has been used to fertilize female bluegills. Half of these females were treated normally and the other half were subjected to pressure shock to induce polar body retention. These treatments are intended to produce fish with exclusively the female genetic complement. The pressure shocked individuals (putative diploid gynogens) showed higher survival and far fewer abnormalities, and several hundred lived long enough to be stocked in a pond at SIU-C. When these fish can be reliably sexed in the coming year, if they are all females, it will prove that in bluegills sex is determined by an XY type chromosomal system.

In 1991, MSU has continued to refine triploid sunfish production techniques using both cold shock and pressure treatments. They were able to produce 100% triploidy in bluegill subjected to cold shock ($t_{\text{after fertilization}} = 1.5$ min at 5 °C for 10 min) or pressure treatments ($t_{\text{after fertilization}} = 1.5$ min at 8000 psi for 5 min.). They are currently evaluating survival from the various 100% triploid treatments before final recommendations can be made. A large number of triploids are being produced for testing of growth and survival next year at SIU-C.

MSU also produced the first tetraploid bluegills using cold shock. Tetraploids mated with normal diploid bluegill should absolutely insure 100% sterile triploid offspring.

At SIU-C, the growth performance of bluegills, green sunfish, and bluegill cross-green sunfish hybrids across the temperature range of 8-28 °C, is currently being evaluated in trials begun with 5 g fish. Preliminary results suggest that all three types of sunfish are capable of growth of about 4% body weight per day, exhibited some growth even as low as 8 °C and had very good growth at higher temperatures. Also at SIU-C, growth, survival and food conversion of hybrid sunfish held in cages at densities of 100, 200, and 400 fish per m³ have been examined. Although analysis is not complete, the most significant findings from this study are: (1) growth at 400 fish/m³ was lower than at 100 or 200 fish/m³, (2) mortality was not related to density, (3) food conversion was lower at the high density, and (4) pond differences can have a significant effect on growth.

USEFULNESS OF FINDINGS

Triploid bluegills are sterile and can be used in production ponds to reduce overpopulation and stunting of sunfish that normally results with uncontrolled reproduction. The reliability of 100% triploid production is very important for food fish producers and recreational fisheries managers. Even a few normal diploid fish that reproduce can result in loss of numbers control. The reliable pressure shock treatments developed at SIU-C and the tetraploid sunfish produced at MSU both can contribute to the production of new aquaculture products which can be sold to farm ponds owners and others interested in developing recreational fisheries.

Preliminary results of cage culture trials indicate that rearing densities should be less than 400 fish/m³.

WORK PLANNED FOR NEXT YEAR

SIU-C will produce triploids for lab and field production trials. The diploid gynogens currently being reared will be sexed to elucidate the genetic determination mechanism in bluegill.

MSU researchers will refine techniques of producing tetraploid bluegills, and rear them to maturity to test tetraploid X tetraploid, tetraploid X diploid, and diploid X tetraploid crosses.

Growth performance trials with parental *Lepomis* species, hybrids, and triploid hybrid bluegills will continue. Sunfish stocks best suited to be developed for commercial aquaculture in the North Central Region will thus be identified.

The trials testing the effects of density on sunfish rearing will be repeated using triploid individuals. In addition, diploid hybrid sunfish will be reared at three densities in triplicate ponds to determine the optimum rearing density for this form of aquaculture.

PUBLICATIONS OR MANUSCRIPTS

Accepted manuscripts:

Tetzlaff, B., and P. Wills. (In press). Current trends in the culture of hybrid sunfish. Pages 214-218 in *Proceedings of North Central Aquaculture Conference*, Kalamazoo, Michigan, March 18-21, 1991.

Westmas, A.R., W. Young, and D. Garling. (In press). Induction of polyploids in bluegills and chinook salmon. Pages 110-112 in *Proceedings of North Central Aquaculture Conference*, Kalamazoo, Michigan, March 18-21, 1991.

Submitted manuscript:

Wills, P., R. Sheehan, and J. Paret. Ploidy and induced ploidy in *Lepomis* sunfish hybrids. Transactions of the American Fisheries Society

G. Culture Technology of Salmonids

for the period
September 1, 1990 to August 31, 1991

TOTAL FUNDS COMMITTED: \$129,799

WORK GROUP MEMBERS:

Paul B. Brown, Chair	Purdue University	Indiana
Donald L. Garling	Michigan State University	Michigan
Anne R. Kapuscinski	University of Minnesota	Minnesota
James E. Seeb	Southern Illinois University-Carbondale	Illinois
Robert J. Sheehan	Southern Illinois University-Carbondale	Illinois
 Extension Liaison:		
Ronald E. Kinnunen	Michigan State University	Michigan

PROGRESS OF THE WORK GROUP AND PRINCIPAL ACCOMPLISHMENTS

This project is designed to improve regional competitiveness in salmonid aquaculture through an interdisciplinary research approach. Major initiatives include work on genetics and development of regional brood stock and improved understanding of dietary formulations that will reduce the pollution associated with aquaculture effluents.

Sex-reversed gynogenetic rainbow trout have been produced in the region and are under evaluation at a private aquaculture facility (Seven Pines Trout Farm, Lewis, Wisconsin) and at Southern Illinois University-Carbondale. Further evaluations will be conducted in the region in the coming year.

Research on development of less-polluting diets has resulted in the definition of methods for use in these types of studies and verified that dietary additives such as transgenically-produced phytase will improve digestion or absorption of phosphorus from plant feedstuffs. Further growth studies are underway with the new low- phosphorus diets.

USEFULNESS OF FINDINGS

There are serious concerns regarding a source of brood stock in the North Central Region, primarily because of the potential for disease transmission. Thus, development of a regional source of brood stock is needed that will provide the necessary offspring for continued development of salmonid aquaculture. Further, many of the genetically-manipulated fish that are being developed in this project have been shown to have superior performance characteristics in other parts of the world and this aspect will be evaluated in our regional conditions and production systems.

Improved genetic lines of salmonids may lead to improved economic viability of salmonid aquaculture and continued expansion in the region. However, there have been serious concerns regarding the pollutional aspect of aquaculture effluents on receiving bodies of water which may limit industrial development. The primary nutrients considered in this area are phosphorus and nitrogen. The research initiated in this project will lead to lower levels of phosphorus in diets fed to trout, maximize absorption of phosphorus, and decrease phosphorus in aquaculture effluents. Further, evaluation of new dietary additives such as phytase will allow increased use of plant protein feedstuffs such as soybean products that contain a nutritionally-unavailable form of phosphorus. The combined effort in this area may result in regionally manufactured salmonid diets using feedstuffs that are already present and cost effective.

WORK PLANNED FOR NEXT YEAR

Continued performance evaluations will be conducted with genetically-manipulated fish in conditions and production systems used in the North Central region. Additionally, work on development of Atlantic salmon gynogens will continue and will focus on development of optimal conditions.

Work on less-polluting diets will focus on further evaluations of low-phosphorus diets and continued quantification of phosphorus absorption from feedstuffs of both plant and animal origin.

PUBLICATIONS OR MANUSCRIPTS

Accepted manuscript:

Brown, P.B. (In press). Comparison of fecal collection methods for determining phosphorus absorption in rainbow trout. Proceedings of the Fourth International Symposium on Fish Feeds and Nutrition, Biarritz, France.

H. North Central Regional Aquaculture Conference

for the period
September 1, 1990 to August 31, 1991

TOTAL FUNDS COMMITTED: \$7,000

PROJECT LEADER:

Donald L. Garling

Michigan State University

Michigan

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS

The purpose of this project is to provide a forum for exchange of information and technology transfer between aquaculturists in the private and public sectors in the North Central Region as well as surrounding states and provinces of Canada.

Funds provided for this project were used for the initial costs of planning and advertising the first North Central Aquaculture Conference (NCAC) that was held March 18-21, 1991 in Kalamazoo, Michigan. Registration fees from that conference will be used for the next conference that is slated for 1993; with additional conferences scheduled every two years thereafter. Approximately 240 people participated in the first NCAC which was co-hosted by NCRAC; the Michigan Department of Natural Resources, Fish Division; Illinois Department of Conservation, Fish Division; Michigan Fish Growers' Association; and Michigan Cooperative Extension Service. A published proceedings is to be available by late fall 1991.